

What is Claimed is:

1. A surface shape recognition sensor

2 comprising:

3 a plurality of capacitive detection elements  
4 formed from lower electrodes and a deformable plate-like  
5 upper electrode made of a metal, the lower electrodes  
6 being insulated and isolated from each other and  
7 stationarily laid out on a single plane of an interlevel  
8 dielectric formed on a semiconductor substrate, and the  
9 upper electrode being laid out above the lower  
10 electrodes at a predetermined interval and having a  
11 plurality of opening portions;

12 a support electrode laid out around the lower  
13 electrodes while being insulated and isolated from the  
14 lower electrodes, and formed to be higher than the lower  
15 electrodes to support the upper electrode;

16 a protective film formed on the upper  
17 electrode to close the opening portions; and

18 a plurality of projections laid out in a  
19 region of said protective film above said capacitive  
20 detection element.

2. A sensor according to claim 1, wherein said  
2 protective film and projections are integrally formed.

3. A sensor according to claim 1, wherein said

2 support electrode is made of a metal.

4. A sensor according to claim 1, wherein  
2 said sensor comprises an electrode dielectric  
3 film laid out on the lower electrode, and  
4 the upper electrode is laid out above said  
5 electrode dielectric film at a predetermined interval.

5. A sensor according to claim 4, wherein  
2 letting A be a moving amount of a central portion of the  
3 upper electrode when the upper electrode deforms at  
4 maximum within an elastic deformation range, the  
5 interval between the upper electrode and said electrode  
6 dielectric film is not more than A.

6. A sensor according to claim 4, wherein said  
2 electrode dielectric film is formed into substantially  
3 the same shape as that of the lower electrode and laid  
4 out to cover the lower electrode.

7. A surface shape recognition sensor  
2 comprising:  
3 a plurality of capacitive detection elements  
4 formed from lower electrodes and a deformable plate-like  
5 upper electrode made of a metal, the lower electrodes  
6 being insulated and isolated from each other and  
7 stationarily laid out on a single plane of an interlevel

8 dielectric formed on a semiconductor substrate, and the  
9 upper electrode being laid out above the lower  
10 electrodes at a predetermined interval and having a  
11 plurality of opening portions;  
12 a support electrode laid out around the lower  
13 electrodes while being insulated and isolated from the  
14 lower electrodes, and formed to be higher than the lower  
15 electrodes to support the upper electrode;  
16 a protective film formed on the upper  
17 electrode to close the opening portions; and  
18 a projection made of a metal and laid out in a  
19 region of said protective film above said capacitive  
20 detection element.

8. A sensor according to claim 7, wherein said  
2 projection is laid out in a region above the lower  
3 electrode.

9. A sensor according to claim 7, wherein a  
2 plurality of projections are laid out in the region  
3 above said capacitive detection element.

10. A sensor according to claim 7, wherein said  
2 support electrode is made of a metal.

11. A sensor according to claim 7, wherein  
2 said sensor comprises an electrode dielectric

3 film laid out on the lower electrode, and  
4 the upper electrode is laid out above said  
5 electrode dielectric film at a predetermined interval.

12. A sensor according to claim 11, wherein  
2 letting A be a moving amount of a central portion of the  
3 upper electrode when the upper electrode deforms at  
4 maximum within an elastic deformation range, the  
5 interval between the upper electrode and said electrode  
6 dielectric film is not more than A.

13. A sensor according to claim 11, wherein said  
2 electrode dielectric film is formed into substantially  
3 the same shape as that of the lower electrode and laid  
4 out to cover the lower electrode.

14. A method of manufacturing a surface shape  
2 recognition sensor, comprising the steps of:  
3 forming an interlevel dielectric on a  
4 semiconductor substrate;  
5 forming a first metal film on the interlevel  
6 dielectric;  
7 forming a first mask pattern having an opening  
8 portion in a predetermined region on the first metal  
9 film;  
10 forming a first metal pattern on a surface of  
11 the first metal film exposed to a bottom portion of the

12 opening portion of the first mask pattern by plating;  
13 after the first mask pattern is removed,  
14 forming a second mask pattern having an opening portion  
15 laid out around the first metal pattern on the first  
16 metal film and first metal pattern;  
17 forming a second metal pattern thicker than  
18 the first metal pattern on the surface of the first  
19 metal film exposed to a bottom portion of the opening  
20 portion of the second mask pattern by plating;  
21 after the second mask pattern is removed,  
22 etching and removing the first metal film using the  
23 first and second metal patterns as a mask to form a  
24 lower electrode formed from the first metal film and  
25 first metal pattern and a support electrode formed from  
26 the first metal film and second metal pattern;  
27 forming a sacrificial film on the interlevel  
28 dielectric to cover the lower electrode while keeping an  
29 upper portion of the support electrode exposed;  
30 forming an upper electrode having a plurality  
31 of opening portions on the sacrificial film and support  
32 electrode;  
33 after the upper electrode is formed,  
34 selectively removing only the sacrificial film through  
35 the opening portions;  
36 after the sacrificial film is removed, forming  
37 a protective film on the upper electrode;  
38 forming a photosensitive resin film having

39 photosensitivity on the protective film; and  
 40 forming a plurality of projections in a region  
 41 of the protective film above a capacitive detection  
 42 element by exposing and developing a predetermined  
 43 pattern on the photosensitive resin film,  
 44 wherein a plurality of capacitive detection  
 45 elements each having the lower electrode and upper  
 46 electrode are formed.

15. A method according to claim 14, wherein the  
 2 protective film is formed on the upper electrode by  
 3 transfer.

16. A method according to claim 15, wherein in  
 2 the protective film transfer step, STP is used as a  
 3 transfer method.

17. A method according to claim 15, wherein  
 2 the lower electrode formation step comprises  
 3 the steps of forming the first metal film on the  
 4 semiconductor substrate, forming a first patterned  
 5 resist on the first metal film, forming the lower  
 6 electrode in an opening portion of the first resist, and  
 7 removing the first resist,  
 8 the support electrode formation step comprises  
 9 the steps of forming a second patterned resist on the  
 10 first metal film, forming the support electrode in an

11 opening portion of the second resist, removing the  
12 second resist, and etching the first metal film using  
13 the lower electrode and support electrode as a mask,  
14 the upper electrode formation step comprises  
15 the steps of forming the sacrificial film on the lower  
16 electrode and support electrode, removing the  
17 sacrificial film on the support electrode to expose the  
18 support electrode, forming a second metal film on the  
19 support electrode and sacrificial film, forming a third  
20 patterned resist on the second metal film, forming the  
21 upper electrode in an opening portion of the third  
22 resist, removing the third resist, etching the second  
23 metal film using the upper electrode as a mask, and  
24 removing the sacrificial film,  
25 the protective film transfer step comprises  
26 the step of transferring the protective film onto the  
27 upper electrode by STP,  
28 the photosensitive resin film formation step  
29 comprises the step of applying the photosensitive resin  
30 film onto the protective film, and  
31 the step of fabricating the photosensitive  
32 resin film into the projections comprises the steps of  
33 exposing part of the photosensitive resin film and  
34 executing development after exposure.

18. A method according to claim 14, wherein the  
2 sacrificial film is essentially formed from a polyimide

3 resin.

19. A method according to claim 14, wherein the  
2 sacrificial film is essentially formed from a  
3 polybenzoxazole precursor resin.

20. A method according to claim 14, wherein the  
2 sacrificial film is removed by heating the sacrificial  
3 film and simultaneously exposing the sacrificial film to  
4 an ozone ambient.

21. A method according to claim 14, wherein the  
2 lower electrode, support electrode, and upper electrode  
3 are essentially formed from gold.

22. A method according to claim 14, wherein  
2 the upper electrode is formed on the  
3 sacrificial film and support electrode while separating  
4 the opening portions from a side wall of the support  
5 electrode, and  
6 after the sacrificial film is removed, a  
7 liquid material is applied onto the upper electrode to  
8 form a coat, and the coat is hardened to form the  
9 protective film on the upper electrode to close the  
10 opening portions.

23. A method according to claim 22, wherein in



2 forming the coat, the coat is laid out on a force acting  
3 side of th substrate and hardened.

24. A method according to claim 23, wherein in  
2 forming the coat, the coat is laid out on a lower side  
3 of the substrate and hardened.

25. A method according to claim 22, wherein  
2 letting t be a thickness of the coat in a  
3 region other than the opening portions in forming the  
4 coat,

5 a be a sectional area of the opening portion  
6 at a boundary between the opening portion and an  
7 external portion of a space formed between the upper  
8 electrode and the lower electrode,

9 b be a peripheral length of a section of the  
10 opening portion at a boundary between the space and the  
11 opening portion,

12 c be a volume in the opening portion,

13 d be the magnitude of surface tension, at the  
14 boundary between the space and the opening portion,  
15 between an opening portion inner wall and a portion of  
16 the coat that has entered the opening portion,

17 e be a density of the coat, and

18 g be a gravitational acceleration,

19 a relationship given by

20 
$$(c + a \times t) \times e \times g \leq b \times d$$

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21 is satisfied.

26. A method according to claim 22, wherein

2 the upper electrode is formed by plating gold  
3 on and around the sacrificial film, and

4 the coat is formed by applying the liquid  
5 material formed from polyimide.

27. A method according to claim 26, wherein

2 the coat is formed by applying the liquid  
3 material formed from polyimide having photosensitivity,  
4 and

5 the protective film is formed in an opening  
6 portion region on the upper electrode to close the  
7 opening portions by removing a region of the coat other  
8 than a peripheral region of the opening portions by  
9 photolithography and hardening a remaining portion.

28. A method according to claim 14, wherein

2 before the sacrificial film is formed,

3 a first dielectric film that is lower than the  
4 support electrode and covers the lower electrode is  
5 formed on the lower electrode, and

6 the first dielectric film is selectively  
7 removed to form an electrode dielectric film on the  
8 lower electrode.

29. A method according to claim 14, wherein

after the first metal pattern is formed,

a first dielectric film is formed on the first metal pattern to cover the first metal pattern,

the first mask pattern is removed to form an electrode dielectric film on the first metal pattern, and then,

the second mask pattern is formed.

30. A method according to claim 14, wherein

after the first mask pattern is removed, a first dielectric film is formed on the first metal pattern to cover the first metal pattern,

the first dielectric film is selectively removed to form an electrode dielectric film on the first metal pattern, and

after the electrode dielectric film is formed, the second mask pattern is formed.

31. A method of manufacturing a surface shape

recognition sensor, comprising the steps of:

forming an interlevel dielectric on a semiconductor substrate;

forming a first metal film on the interlevel dielectric;

forming a first mask pattern having an opening portion in a predetermined region on the first metal

9 film;

10 forming a first metal pattern on a surface of

11 the first metal film exposed to a bottom portion of the

12 opening portion of the first mask pattern by plating;

13 after the first mask pattern is removed,

14 forming a second mask pattern having an opening portion

15 laid out around the first metal pattern on the first

16 metal film and first metal pattern;

17 forming a second metal pattern thicker than

18 the first metal pattern on the surface of the first

19 metal film exposed to a bottom portion of the opening

20 portion of the second mask pattern by plating;

21 after the second mask pattern is removed,

22 etching and removing the first metal film using the

23 first and second metal patterns as a mask to form a

24 lower electrode formed from the first metal film and

25 first metal pattern and a support electrode formed from

26 the first metal film and second metal pattern;

27 forming a sacrificial film on the interlevel

28 dielectric to cover the lower electrode while keeping an

29 upper portion of the support electrode exposed;

30 forming an upper electrode having a plurality

31 of opening portions on the sacrificial film and support

32 electrode;

33 after the upper electrode is formed,

34 selectively removing only the sacrificial film through

35 the opening portions;

36           after the sacrificial film is removed, forming  
37 a photosensitive resin film having photosensitivity on  
38 the upper electrode; and  
39           simultaneously forming a protective film that  
40 covers the upper electrode and a plurality of  
41 projections laid out in a region of the protective film  
42 above a capacitive detection element by exposing and  
43 developing a predetermined pattern on the photosensitive  
44 resin film,  
45           wherein a plurality of capacitive detection  
46 elements each having the lower electrode and upper  
47 electrode are formed.

32.           A method according to claim 31, wherein the  
2 photosensitive resin film is formed on the upper  
3 electrode by transfer.

33.           A method according to claim 32, wherein in  
2 the photosensitive resin film transfer step, STP is used  
3 as a transfer method.

34.           A method according to claim 32, wherein  
2           the lower electrode formation step comprises  
3 the steps of forming the first metal film on the  
4 semiconductor substrate, forming a first patterned  
5 resist on the first metal film, forming the lower  
6 electrode in an opening portion of the first resist, and

7 removing the first resist,

8 the support electrode formation step comprises

9 the steps of forming a second patterned resist on the

10 first metal film, forming the support electrode in an

11 opening portion of the second resist, removing the

12 second resist, and etching the first metal film using

13 the lower electrode and support electrode as a mask,

14 the upper electrode formation step comprises

15 the steps of forming the sacrificial film on the lower

16 electrode and support electrode, removing the

17 sacrificial film on the support electrode to expose the

18 support electrode, forming a second metal film on the

19 support electrode and sacrificial film, forming a third

20 patterned resist on the second metal film, forming the

21 upper electrode in an opening portion of the third

22 resist, removing the third resist, etching the second

23 metal film using the upper electrode as a mask, and

24 removing the sacrificial film,

25 the photosensitive resin film transfer step

26 comprises the step of transferring the photosensitive

27 resin film onto the upper electrode by STP, and

28 the step of forming the protective film and

29 the plurality of projections on the protective film

30 comprises the steps of exposing part of the

31 photosensitive resin film and executing development

32 after exposure.

35. A method according to claim 31, wherein the  
2 sacrificial film is essentially formed from a polyimide  
3 resin.

36. A method according to claim 31, wherein the  
2 sacrificial film is essentially formed from a  
3 polybenzoxazole precursor resin.

37. A method according to claim 31, wherein the  
2 sacrificial film is removed by heating the sacrificial  
3 film and simultaneously exposing the sacrificial film to  
4 an ozone ambient.

38. A method according to claim 31, wherein the  
2 lower electrode, support electrode, and upper electrode  
3 are essentially formed from gold.

39. A method according to claim 31, wherein  
2 before the sacrificial film is formed,  
3 a first dielectric film that is lower than the  
4 support electrode and covers the lower electrode is  
5 formed on the lower electrode, and  
6 the first dielectric film is selectively  
7 removed to form an electrode dielectric film on the  
8 lower electrode.

40. A method according to claim 31, wherein

2 after the first metal pattern is formed,  
3 a first dielectric film is formed on the first  
4 metal pattern to cover the first metal pattern,  
5 the first mask pattern is removed to form an  
6 electrode dielectric film on the first metal pattern,  
7 and then,  
8 the second mask pattern is formed.

41. A method according to claim 31, wherein  
2 after the first mask pattern is removed, a  
3 first dielectric film is formed on the first metal  
4 pattern to cover the first metal pattern,  
5 the first dielectric film is selectively  
6 removed to form an electrode dielectric film on the  
7 first metal pattern, and  
8 after the electrode dielectric film is formed,  
9 the second mask pattern is formed.

42. A method of manufacturing a surface shape  
2 recognition sensor, comprising the steps of:  
3 forming an interlevel dielectric on a  
4 semiconductor substrate;  
5 forming a first metal film on the interlevel  
6 dielectric;  
7 forming a first mask pattern having an opening  
8 portion in a predetermined region on the first metal  
9 film;



10           forming a first metal pattern on a surface of  
11 th first metal film exposed to a bottom portion of the  
12 opening portion of the first mask pattern by plating;  
13           after the first mask pattern is removed,  
14 forming a second mask pattern having an opening portion  
15 laid out around the first metal pattern on the first  
16 metal film and first metal pattern;  
17           forming a second metal pattern thicker than  
18 the first metal pattern on the surface of the first  
19 metal film exposed to a bottom portion of the opening  
20 portion of the second mask pattern by plating;  
21           after the second mask pattern is removed,  
22 etching and removing the first metal film using the  
23 first and second metal patterns as a mask to form a  
24 lower electrode formed from the first metal film and  
25 first metal pattern and a support electrode formed from  
26 the first metal film and second metal pattern;  
27           forming a sacrificial film on the interlevel  
28 dielectric to cover the lower electrode while keeping an  
29 upper portion of the support electrode exposed;  
30           forming an upper electrode having a plurality  
31 of opening portions on the sacrificial film and support  
32 electrode;  
33           after the upper electrode is formed,  
34 selectively removing only the sacrificial film through  
35 the opening portions;  
36           after the sacrificial film is removed, forming

37 a protective film on the upper electrode;  
 38 forming a second metal film on the protective  
 39 film;  
 40 forming a third mask pattern having an opening  
 41 portion in a predetermined region on the second metal  
 42 film;  
 43 forming a third metal pattern on a surface of  
 44 the second metal film exposed to a bottom portion of the  
 45 opening portion of the third mask pattern by plating;  
 46 and  
 47 after the third mask pattern is removed,  
 48 etching and removing the second metal film using the  
 49 third metal pattern as a mask to form a projection  
 50 formed from the second metal film and third metal  
 51 pattern  
 52 wherein a plurality of capacitive detection  
 53 elements each having the lower electrode and upper  
 54 electrode are formed.

43. A method according to claim 42, wherein the  
 2 protective film is formed on the upper electrode by  
 3 transfer.

44. A method according to claim 43, wherein in  
 2 the protective film transfer step, STP is used as a  
 3 transfer method.

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45. A method according to claim 42, wherein the  
2 sacrificial film is essentially formed from a polyimide  
3 resin.

46. A method according to claim 42, wherein the  
2 sacrificial film is essentially formed from a  
3 polybenzoxazole precursor resin.

47. A method according to claim 42, wherein the  
2 sacrificial film is removed by heating the sacrificial  
3 film and simultaneously exposing the sacrificial film to  
4 an ozone ambient.

48. A method according to claim 42, wherein the  
2 lower electrode, support electrode, and upper electrode  
3 are essentially formed from gold.

49. A method according to claim 42, wherein  
2 the upper electrode is formed on the  
3 sacrificial film and support electrode while separating  
4 the opening portions from a side wall of the support  
5 electrode, and

6 after the sacrificial film is removed, a  
7 liquid material is applied onto the upper electrode to  
8 form a coat, and the coat is hardened to form the  
9 protective film on the upper electrode to close the  
10 opening portions.

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50. A method according to claim 49, wherein in  
2 forming the coat, the coat is laid out on a force acting  
3 side of the substrate and hardened.

51. A method according to claim 50, wherein in  
2 forming the coat, the coat is laid out on a lower side  
3 of the substrate and hardened.

52. A method according to claim 49, wherein  
2 letting  $t$  be a thickness of the coat in a  
3 region other than the opening portions in forming the  
4 coat,

5  $a$  be a sectional area of the opening portion  
6 at a boundary between the opening portion and an  
7 external portion of a space formed between the upper  
8 electrode and the lower electrode,

9  $b$  be a peripheral length of a section of the  
10 opening portion at a boundary between the space and the  
11 opening portion,

12  $c$  be a volume in the opening portion,

13  $d$  be the magnitude of surface tension, at the  
14 boundary between the space and the opening portion,  
15 between an opening portion inner wall and a portion of  
16 the coat that has entered the opening portion,

17  $e$  be a density of the coat, and

18  $g$  be a gravitational acceleration,

19 a relationship given by

20  $(c + a \times t) \times e \times g \leq b \times d$

21 is satisfied.

53. A method according to claim 49, wherein

2 the upper electrode is formed by plating gold  
3 on and around the sacrificial film, and

4 the coat is formed by applying the liquid  
5 material formed from polyimide.

54. A method according to claim 53, wherein

2 the coat is formed by applying the liquid  
3 material formed from polyimide having photosensitivity,  
4 and

5 the protective film is formed in an opening  
6 portion region on the upper electrode to close the  
7 opening portions by removing a region of the coat other  
8 than a peripheral region of the opening portions by  
9 photolithography and hardening a remaining portion.

55. A method according to claim 42, wherein

2 before the sacrificial film is formed,

3 a first dielectric film that is lower than the  
4 support electrode and covers the lower electrode is  
5 formed on the lower electrode, and

6 the first dielectric film is selectively  
7 removed to form an electrode dielectric film on the

8 lower electrode.

56. A method according to claim 42, wherein  
2 after the first metal pattern is formed,  
3 a first dielectric film is formed on the first  
4 metal pattern to cover the first metal pattern,  
5 the first mask pattern is removed to form an  
6 electrode dielectric film on the first metal pattern,  
7 and then,  
8 the second mask pattern is formed.

57. A method according to claim 42, wherein  
2 after the first mask pattern is removed, a  
3 first dielectric film is formed on the first metal  
4 pattern to cover the first metal pattern,  
5 the first dielectric film is selectively  
6 removed to form an electrode dielectric film on the  
7 first metal pattern, and  
8 after the electrode dielectric film is formed,  
9 the second mask pattern is formed.